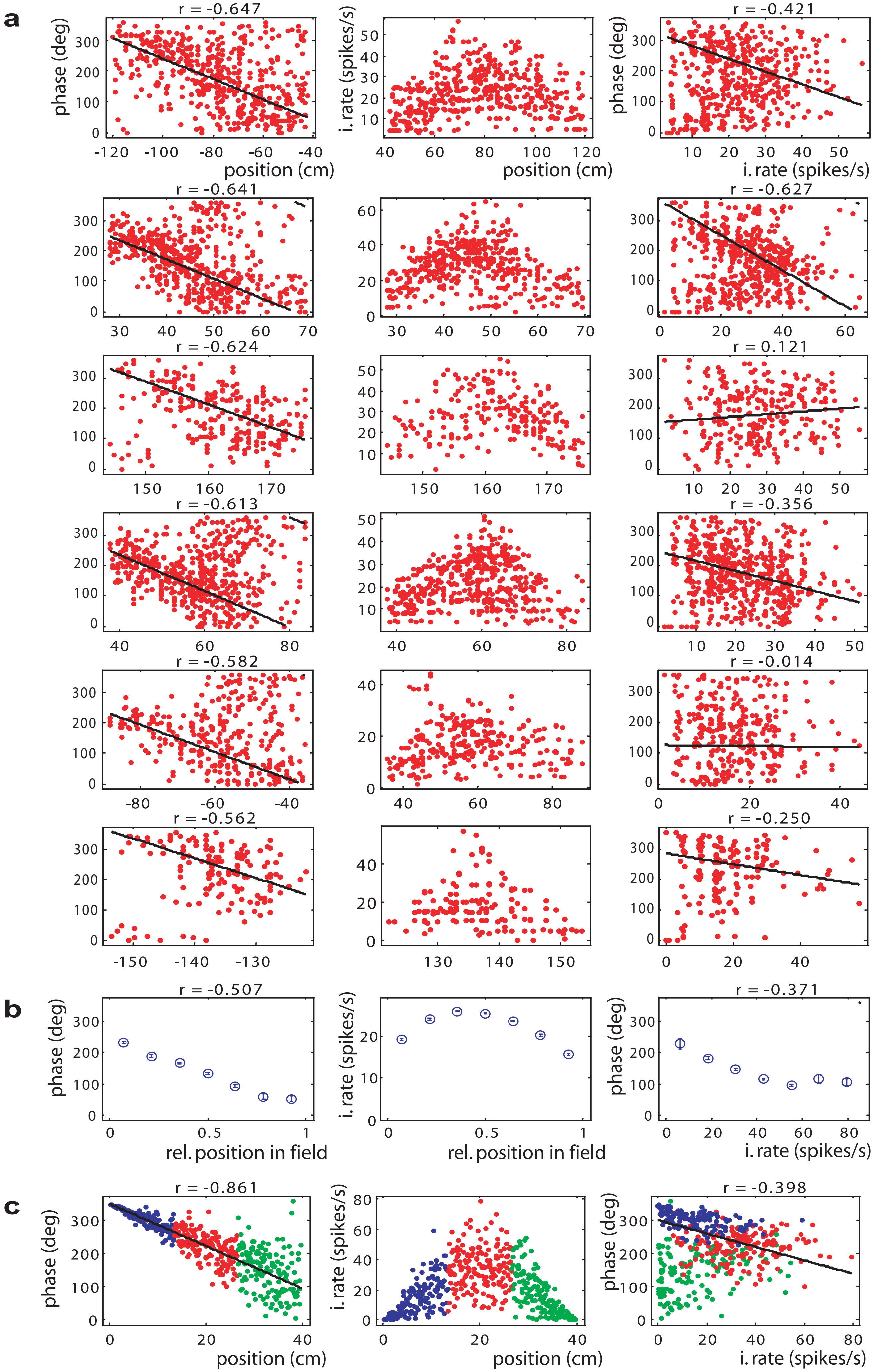
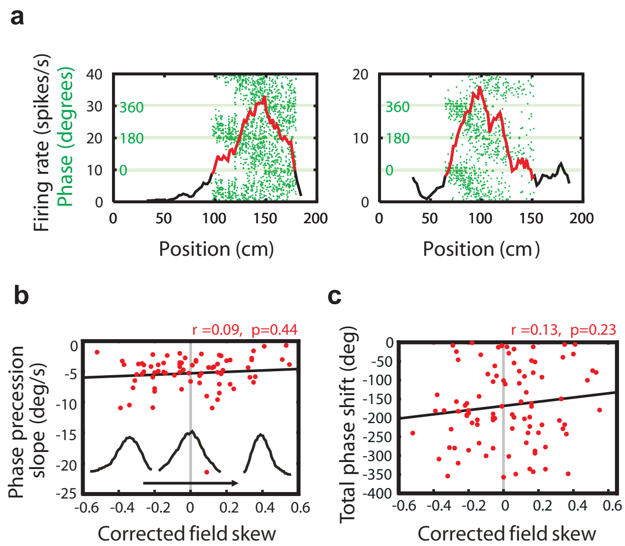
Supplementary Figure 1. A relationship between place cell firing phase and instantaneous firing rate exists when rats run on a linear track, but may derive from the variation of firing phase and firing rate with the rat's position on the track.
a) Scatter plots showing the relationship between phase and position, rate and position, and phase and rate for 6 CA1 place fields on a linear track. Correlation coefficients (r) and associated regression lines, taking account of the circular nature of phase, show the greater range and strength of the variation of phase with position than with rate. See Figure 1g for population summary statistics. See Methods for details.
b) Analysis of spikes pooled across cells, as in Harris et al., (2002), showing the relationship between phase and position, rate and position, and phase and rate (25158 spikes, 77 fields). Points show the appropriate (circular or linear) mean, error bars show the appropriate (circular or linear) standard error. Rat position data was scaled to reflect the proportion of the way through each field. This analysis (right plot) combines the absolute phases of spikes from different cells relative to the theta rhythm in the EEG local to the cell, irrespective of cells' different locations and overall firing rates. It replicates the relationship between phase and rate found by Harris et al (2002), but suggests that it derives from the stronger and steeper correlation between phase and position within each cell (Figure 1g).
c) Simulation showing how a weaker and shallower regression of phase on rate can result from a stronger and steeper regression of phase on position. Note (right plot) that the late-field firing (green) influences the regression line less than the early-field firing (blue) due to the increasing variation in phase with position (exaggerated here to clearly demonstrate the effect). The reliability of this subsidiary phase-rate correlation increases with the number of data points, explaining the stronger correlation for the pooled data (r = -0.37, part b above) than for individual cells (mean r = -0.07, see Figure 1g). Data for phase φ and instantaneous rate r were simulated as functions of position in the place field x according to
$\{\varphi, r\} = \{350 - 250x/L + 75\mu_1 x/L,\ 15(1 - (2x/L - 1)^2)(\mu_2 + 2.5(1 - (2x/L - 1)^2))\}$,
where μ_1 and μ_{12} are drawn from a unit Normal distribution and L is the length of the place field.

Supplementary Figure 2. The rate and extent of phase precession are not related to the skew of the place field firing rate distribution. (a) Cells with negative (left) or positive (right) skew show phase precession. Neither (b) rate of phase precession nor (c) total extent of phase shift correlates with field skew. In both (b) and (c), skew has been corrected for running direction, i.e. reversed for cells which fired on runs from east to west.



Supplementary figure 1



Supplementary Figure 2